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FINAL SCIENTIFIC REPORT

AFOSR Grant 81-0107

for

TRANSONIC FLOW RESEARCH

from the

University of Arizona
Tucson, Arizona 85721

Principal Investigator: Dr. K.-Y. Fung

Program Manager: Dr. James D. Wilson
Office of Scientific Research

Period: 1 January 1981 - 30 June 1982

10 December 1982

FINAL SCIENTIFIC REPORT

AFOSR Grant No. 81-0107

Introduction

This final report summarizes our research activities on AFOSR Grant No. 81-0107 from January, 1981 to June, 1982. These research activities, resulted in ten publications and seven oral presentations listed in chronological order in the Appendix, were in part supported by the NASA and the ONR, and some derived from earlier AFOSR support.

Fictitious Gas Design Method

The design technique of using fictitious gas to achieve shock free transonic flight conditions had been studied and extended to the design of wings, airfoils, and supersonic conical bodies. Its practicality and the ability of obtaining near optimal designs have been summarized in the review paper presented at the International Congress of Aeronautical Sciences Meeting, Seattle, Washington.

The new application to the design of supersonic conical bodies was reported in Dr. Sritharan's dissertation and also mentioned in the ICAS paper. Only the example of a circular cone at an angle of incident was given. Hopefully, Dr. Sritharan will be able to complete this study at ICAS where he is a post-doctoral fellow. A general conclusion of this study at this stage is that the applicability of the fictitious method in conical flows is more limited than in plane transonic flows.

Conical Flows

A fully conservative finite area code based on the potential approximation for conical flows has been developed in Dr. Sritharan's dissertation. This work, being the first using finite area approach and one that generalizes Jameson's iteration procedure to general curvilinear systems, was presented at the AIAA Fluid, Plasmadynamics and Heat Transfer Conference, St. Louis, Missouri last June. An application of this code is to design conical bodies at incident with shock free cross flow, mentioned above.

Unsteady Transonic Flow Computations with Input Pressure Distributions

Derived from our earlier belief that an accurate steady pressure distribution with correct shock strength and location is important for the prediction of unsteady transonic responses, an inverse algorithm IAF2, accepting pressure distributions instead of airfoil coordinates, is developed to provide the steady flow fields needed in unsteady computations. This algorithm has been integrated into our version of LTRAN and the time linearized code UTFC developed in our earlier studies. This work was presented at the AIAA Fluid, Plasmadynamics and Heat Transfer Conference. Very good agreement compared with experimental results in predicting phase lags and magnitudes of unsteady responses for attached transonic flows is obtained using this procedure.

Unsteady Wind Tunnel Interference

Alerted by previous research on the proper far-field boundary conditions for unsteady transonic flow, we have concluded in a study, as part of Mr. Przybytkowski's dissertation, that two dimensional wall interferences are most critical in the low reduced frequency range and that resonance conditions can be predicted using linear acoustic theory, with slight modifications due to nonlinear effects. Mr. Przybytkowski is expected to graduate in February with the completion of this study and the extension of it to three dimensional unsteady flows using the code he developed earlier. A paper on these studies is under preparation for the summer AIAA meetings.

Inviscid Flows with Shock Induced Vorticity

In order to compute the flow after a moderately strong shock accurately, we have studied and confirmed the logarithmic nature of the local solution near the shock root and found that the vorticity induced by the curvature of the shock, despite the well known singularity at the root, is finite and given by a formula in terms of the unstream Mach number, and density and the curvature of the body at the shock root. A technical note on this result has been accepted and will appear in the AIAA Journal.

Using this result and shock fitting techniques, Mr. Liang is developing a code solving the stream function and vorticity equation for flows over bodies, in particular, over a cylinder at supercritical Mach numbers. He is expected to finish this study for his doctoral dissertation next summer.

Conclusion

During the course of this research, we have completed various studies in transonic flow, resulting in ten publications, two doctoral dissertations and one master report, and seven presentations. These results reflect not only this support, but also ONR support and prior OSR support. We conclude this report with a list of publications from January, 1981 through August, 1982.

APPENDIX

PAPERS, TALKS 1981-1982

Papers

** 1. Fung, K.-Y., "Vorticity at the Shock Foot in Inviscid Flow," AIAA Journal (to appear).

** 2. Fung, K.-Y., Sobieczky, H. and Seebass, A.R., "Shock-Free Airfoil, Wing and Turbojet Blade Design," ICAS/AIAA Aircraft Systems & Technology Conference, Seattle, Washington, 1982, Preprint ICAS-82-3.7.1.

** 3. Fung, K.-Y. and Chung, A., "Computation of Unsteady Transonic Aerodynamic Responses Using a Prescribed Input Steady State Pressure Distribution," AIAA/ASME 3rd Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, Paper 82-0956, St. Louis, Missouri, 7-11 June, 1982.

** 4. Sritharan, S.S. and Seebass, A.R., "A Finite Area Method for Nonlinear Conical Flows," AIAA/ASME 3rd Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, Paper 82-0995, St. Louis, Missouri, 7-11 June, 1982.

** 5. Fung, K.-Y., "A Model for Unsteady Transonic Indicial Responses," AIAA Journal, Technical Note 82-4188.

*** 6. Seebass, A.R., "Shock-Free Configurations in Two-and Three Dimensional Transonic Flow," MRC Symposium on Transonic, Shock and Mult-dimensional Flows, Advances in Scientific Computing, Academic Press, 1982.

** 7. Hassan, A and Seebass, A.R., "Transonic Airfoils with a Given Pressure Distribution," AIAA Preprint No. 81-1235.

** 8. Fung, K.-Y., Seebass, A.R. and Dickson, L.J., "An Effective Algorithm for Shock-Free Wing Design," AIAA Paper No. 81-1236.

** 9. Seebass, A.R. and Fung, K.-Y., "Unsteady Transonic Flows: Time-Linearized Calculations," Numerical and Physical Aspects of Aerodynamic Flows (to appear). T. Cebeci, editor.

** 10. Fung, K.-Y., "Far-Field Boundary Conditions for Unsteady Transonic Flows," AIAA Journal, Vol. 19, No. 2, pp. 180-183, 1981.

Talks

University of Arizona, Aerospace and Mechanical Engineering Seminar, February, 1982. (Fung)

** AFOSR and ONR joint funding
*** AFOSR, NASA, and ONR joint funding

AIAA/ASME 3rd Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, St. Louis, Missouri, June, 1982. (Two talks- Fung, Sritharan)

13th Congress of the International Council of the Aeronautical Sciences, Seattle, Washington, August, 1982. (Fung)

DFVLR, Göttingen Colloquium, May, 1981. (Fung)

MRC Symposium of Transonic, Shock, and Multi-dimensional Flows, May, 1981. (Seebass)

AIAA 14th Fluid and Plasma Dynamics Conference, June, 1981. (Two talks- Hassan,Seebass